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A DEVICE AND METHOD FOR MANUFACTURING DEVICES COMPRISING AT LEAST ONE CHIP MOUNTED ON A SUPPORT

INS A1

The present invention relates to a method for manufacturing devices composed of at least one microcircuit mounted on a support, for example for producing a smart card.

In certain fields, including that of smart cards, it is necessary to effect the mounting of a microcircuit or chip on a relatively thin and flexible support. In the case of smart cards, it is necessary on the one hand for the presence of the chip not to cause an excess thickness beyond a threshold established by international standards (currently fixed at 50 μm) and on the other hand for the mounting of the chip to be sufficiently secure to allow durable use even when the card is subjected to relatively high bending and twisting stresses.

In a conventional manner, the creation of an excessive thickness is avoided by housing the chip in a cavity provided for this purpose in the thickness of the support.

Figure 1 shows schematically a known example of mounting a chip 6 on a support 2 intended to constitute a smart card. The chip 6 is housed almost entirely in a cavity 3 so that its thickness is included within that of the support 2. The chip 6 has a set of connecting pads 5 on the edges of its surface turned towards the outside of the cavity 3. These pads 5 are connected to respective contacts 7 on the support by wires 9. The contacts 7 can be situated at the bottom of the cavity, or at an intermediate level in a recessed area 11 around the cavity, as in the example illustrated. These contacts 7 are in their turn electrically connected to contact areas 13 intended to allow an ohmic connection with a card reader. These contact areas 13 are housed entirely in the recess 11 so that their thickness is also contained within that of the support 2.

To protect the whole, a coating of protective material 15 is formed, covering the entire area occupied by the cavity 3, the wires 9 and a portion of the internal edges of the contact areas 11.

This conventional technique suffers from several drawbacks. Firstly, the operation consisting of electrically connecting the connecting pads 5 of the chip 6 to the contacts 7 requires the use of very fine and delicate wires 9, thus forming fragile points.

Moreover, the operations of soldering these wires 9 requires a significant amount of tooling and a not insignificant amount of time.

Moreover, the formation of the cavity 3 requires a machining step which is both expensive and weakening for the card.

INS A2

In the light of these problems, the applicant proposes according to the present invention a method for mounting at least one active circuit, such as a chip, on a support making it possible to dispense with the need to form a cavity in the support without for all that creating a prohibitive excess thickness.

To this end, the present invention proposes a method for connecting to a support a chip produced in thin form, glued to a substrate. This type of chip has exceptional thinness, thus conferring a certain degree of mechanical flexibility. The chip is glued to a substrate at the manufacturing stage, the substrate serving amongst other things for the stiffening during the various steps of manufacturing the chip. There are currently on the market chips resulting from this technology, known by the term SOI ("silicon on insulator"), whose overall thickness (the substrate of the active surface plus connecting bumps) is around ten microns. In this regard, reference is made here to the patent document published under the number WO-A-98/02921, which discloses the technology for producing such chips.

However, SOI technology is particularly tricky when it is a case of connecting the chip to a support.

The techniques used at the present time comprise steps of manipulating the thin chip out of its stiffening substrate in order to position it and connect it to connection points on the support. The problem is then posed on the one hand of removing the chip from its substrate and handling the bare chip in order to fix it to its final support.

To resolve this problem, the present invention proposes a method for manufacturing a device having a support associated with at least one microcircuit in the form of a chip, the method being characterised in that it comprises, for the chip or chips, the steps consisting in:

- initially providing for the said chip an assembly composed of a thin chip held by a first face fixed to a substrate and having on a second opposite face at least one connection pad;
- forming, on one face of the support, a communication interface having at least one element for connection with the said chip;
- presenting the said assembly comprising the chip and the substrate against the communication interface, with each pad on the chip positioned against a corresponding connection element of the communication interface;
- connecting each pad with its respective connection element; and
- removing the said substrate from the said first face of the chip.

Thus the present invention makes it possible to manipulate the chips resulting from SOI technology whilst keeping the initial substrate. This substrate is notably maintained when the chip is connected to its connection elements for the support. In this way, the risks of damaging the chip during mounting are reduced to a minimum.

Application of the method according to the invention is particularly advantageous when it is wished to preserve the advantage of the thinness permitted by these thin substrates by associating them with thin supports. Thus the method according to the invention allows the assembly of one or more thin chips directly on the surface of the support and thus to obtain useable thin circuits without having to form a cavity in the support.

In a preferred embodiment, provision is also made for producing the communication interface on a portion of the surface situated in the overall plane of the said face of the support, that is to say the communication interface is formed so as to protrude from the surface of the support, and therefore without forming an indentation of the type illustrated in Figure 1.

A device is then obtained, such as a smart card, where all the elements attached to the support (communication interface and chip) are on the surface.

This is because the present invention makes it possible to use chips with a very high degree of thinness, which allows an acceptable excess thickness

for the metallisation forming the communication interface. In the case of a smart card, this communication interface can include contact areas to make it possible to connect the card to a reader of the "contact" type. It can also be electrically coupled to an antenna integrated into the card in order to form a "contactless" card, the exchange of signals with the chip and possibly its electrical power supply taking place by radio via the antenna.

Advantageously, each pad is connected with its respective connection element by welding with a laser beam.

It is notably possible, by virtue of the invention, to arrange the laser beam so that it passes through the substrate of the substrate and chip assembly. In other words, the welding points (for example bumps) on the chip are irradiated through the substrate. It should be noted in this regard that the substrates used notably in SOI technology are generally transparent to the wavelengths used for laser welding, being generally based on glass. The chip itself is transparent at the thickness envisaged.

In a preferred embodiment of the invention, the laser beam is transmitted by a plurality of optical paths, each directed towards a respective pad on the chip. In this way, the welding of several welding points on the chip can take place in parallel, affording a saving in manufacturing time.

Preferably, each optical path is produced by means of an optical fibre. The optical paths may, for

example, be integrated into the tool which positions and/or holds the chip on its location at the communication interface of the support.

According to one embodiment, each pad is produced from a metal alloy which melts under the laser beam and/or each portion of a connection element intended to be connected to a respective pad is produced from a material which melts under the laser beam.

However, the present invention makes it possible to use other techniques for connecting the chip to its respective connection element, according to the respective material of the pads and connection elements, for example:

- by heat welding, or
- by ultrasonic welding.

When the chip is fixed to its support, a step of depositing a protective layer on the chip after the removal of the substrate can also be carried out.

The invention also relates to a device with an integrated-circuit chip, such as a smart card, label, etc, having a support carrying a communication interface including connection elements connected to the connection pads of the chip. The device is characterised by the fact that the chip is disposed with its front face towards the support, its pads being connected directly to the connection elements of the interface; the chip is disposed above the surface of the support, and the thickness of the connection elements and of the chip with its pads is less than 50 microns.

Ins A3

Other advantages and characteristics of the invention will emerge more clearly from a reading of preferred embodiments, given purely by way of illustrative and non-limitative example, with reference to the accompanying drawings, in which:

- Figure 1, already described, is a diagram in section showing the mounting of a chip in a cavity in a support according to the prior art;
- Figure 2a is a partial plan view of a smart card support including a communication interface;
- Figure 2b is a view in section along the axis II-II' in Figure 2a;
- Figure 3a is a view in section of an assembly including a chip bonded to its substrate according to the SOI "flip chip" technology;
- Figure 3b is a plan view of a wafer including a group of assemblies of Figure 3 before cutting;
- Figure 4 is a view in section of the assembly depicted in Figure 3a positioned on its support;
- Figure 5 depicts a step of welding the assembly depicted in Figure 3a on its support;
- Figure 6 depicts a step of welding the assembly depicted in Figure 3a on its support according to a variant of Figure 5;
- Figure 7 is a view in partial section of a device composed of a chip mounted on its support at the end of the method according to one embodiment of the invention;

- Figure 8 is a partial plan view of a support with its communication interface intended for producing a contactless smart card; and

- Figure 9 is a view in section along the axis IIX-IIX' in Figure 8 showing the step of fixing an assembly including a chip bonded to its substrate according to the SOI "flip chip" technology.

INS A4

Figure 2a depicts a support 2 which, in the example considered, consists of a plastic card intended to constitute a smart card according to established dimensional standards, for example ISO 7810.

To this end, there is created, at the support area 2 intended to receive a microcircuit (hereinafter referred to as a "chip"), a set of pads forming or connected to a communication interface 4. Such a communication interface 4 may, according to circumstances, serve to:

- connect the inputs and outputs of the chip with the outside, notably the card readers; and/or

- provide the necessary interconnections between the chip and elements produced at the support. These elements may be an antenna integrated into the support 2 so as to form a so-called "contactless card", known per se, or other circuit elements integrated in the card (for example one or more other chips), or an electric power supply source.

In the example illustrated, the communication interface 4 is formed on the one hand by interconnection pads 4a for connecting external equipment with the chip by ohmic contact and on the

other hand tracks 4b which connect the interconnection pads to the chip, as will be described below.

The communication interface 4 is formed on a portion of a surface of one of the faces 2a of the support 2 situated on the same plane as the remainder of this face 2a, as shown in Figure 2b. In other words, the portion of a surface containing the communication interface 4 is not recessed below the plane of the face 2a, as would be the case with a cavity or recess. Thus the communication interface 4 forms an excess thickness vis-à-vis the surface 2a of the support 2.

The communication interface 4 is produced according to techniques which allow the deposition of electrically conductive material intended to form this interface with a slight thickness e1 (Figure 2b). By way of example, the thickness e1 of the communication interface 4 is around 5 to 15 microns.

Several techniques known per se can be envisaged for producing this communication interface 4. In the example, the communication interface 4 is produced by printing, by means of a conductive ink containing particles of silver, conductive plates having the preformed configuration of the pads 4a and tracks 4b. It can also be envisaged producing the communication interface 4 by metallisation according to techniques of screen printing, vacuum deposition, etc. The conductive material used is typically based on copper, nickel or aluminium. This material may be incorporated in a binder adapted to the technique used.

The chip is produced according to a technology for obtaining a very thin substrate so that the chip can be deposited on the communication interface 4.

In the present embodiment, the microcircuit is produced according to SOI technology, that is to say silicon on insulator, making it possible to obtain particularly thin chips. The aspects specific to this technology are known, notably through the patent document WO-A-98/02921.

An example of an assembly including a chip and its substrate according to this SOI technology are depicted in Figures 3a and 3b.

Figure 3a is a view in longitudinal section which depicts a chip 6 mounted on an insulating substrate 8, in this case made from glass. The chip 6 is held fixed on the glass substrate 8 by adhesive pads 10. Thus the chip 6, its insulating substrate 8 and the adhesive pads 10 constitute an assembly, cut from a slice (cf Figure 3b).

As shown more clearly in Figure 3b, which depicts a plan view of a set of chips 6 on the substrate 8, the adhesive pads 10 hold the chip only by the corners thereof. Apart from the edges of the glass substrate 8, each adhesive pad 10 has a rectangular shape whose sides are turned by 45° with respect to the sides of the chip 6, and hold on the substrate 8 four grouped-together corners of four respective chips 6. The chips 6 are thereby held on the glass substrate 8 only by their corners.

The face 6a of the chip 6 opposite to that 6b facing the glass substrate 8 has a series of conductive protrusions 12 protruding slightly from this face 6a. The conductive protrusions 12, generally known by the English term "bumps", constitute the points of interconnection between the circuits of the chip 6 and the outside. These bumps 12 have a generally ogival shape allowing penetration into a material in the molten phase, for example by welding.

In the example, a single chip 6 is intended to be received on the aforementioned communication interface 4. The arrangement of the bumps 12 corresponds to that of the conductive tracks 4b or a portion of the interconnection pads 4a.

Each chip 6 is then cut from the set of chips with the portion of glass substrate 8 and the adhesive pad 10 situated directly under the chip 6. In this way a cut-out assembly is obtained, including the chip 6, portions of adhesive 10 at the corners of the chip and a portion of glass substrate 8 substantially to the dimensions of the chip (Figure 3a).

As shown in Figure 4, this assembly is positioned on the communication interface 4 produced on the support 2, with the bumps 12 aligned with the portions of respective tracks 4b in order to effect the necessary interconnections.

It should be noted that, when the chip 6 is positioned on its definitive support (which is here the plastic support 2 which constitutes the body of the smart card), the face 6a defined previously is no

longer turned outwards, but facing this support 2. In other words, it undergoes a turning through 180° between its configuration just after its manufacture and its definitive positioning. This technique of turning the chip 6 with respect to its original substrate is known by the English term "flip chip".

Once the chip 6 is correctly positioned, the bumps 12 are fixed with respect to the respective connection points (which are here portions of tracks 4b).

In the preferred embodiment of the invention, this fixing is effected by applying energy through the original substrate 8 of the chip 6. This energy is supplied by a laser 14 which transmits a beam 16 directed against the face 8a of the substrate turned outwards. The beam 16 passes right through the thickness of the substrate 8 and the thickness of the chip 6 on an axis containing a bump 12, so as to transfer heat energy thereto.

This heat energy absorbed at the bump 12 allows the bump 12 to melt, the latter being produced from an easily fusible metal alloy such as tin or lead.

When a bump is thus welded, the laser 14 is moved in order to be placed in the axis of the following bump, and to carry out the welding thereof.

Each bump 12 is thus welded by the laser beam 16 on its corresponding connection point 4b of the communication interface 4.

In a variant, it is possible to produce welding pads at the points 4b of the communication interface 4 intended to receive the respective bumps 12. These

pads are then produced from a material able to melt under the thermal energy transferred by the laser beam 16, through the respective bumps 12 in order to weld the latter.

In the example, the glass making up the substrate 8 is transparent to the wavelengths of the laser beams normally used for microwelding. It is notably possible to use for the welding a laser of the YAGNd type emitting a wavelength of 1.06 microns.

The laser 14 can be mounted on a positioning robot 18 enabling the laser beam 16 to be aligned successively with each bump 12 on the chip 6 held in position on its support 2.

Figure 6 depicts a variant according to which several weldings of bumps 12 are carried out simultaneously using a laser 14 by means of a set of optical paths 20 each transporting a laser beam 16 to respective positions in alignment with a bump 12. The optical paths 20 can consist of optical fibres. In this case, at least one optical fibre is positioned perpendicularly opposite the face 8a of the glass substrate 8 (the one turned towards the outside in the assembly position) vertically in line with each bump 12. The energy transmitted by the fibres 20 effects the welding as described previously. The power of the laser 14 will be adapted to the number of optical paths used. If necessary, it is possible to use several different laser sources to supply the optical paths.

The ends 20a of the fibres can be integrated into the tool for positioning and holding the chip vis-à-vis the support 2. The ends 20a of the fibres are disposed according to the configuration of the bumps 12 to be welded on the communication interface 4. It is possible to provide for this purpose a frame enabling several chips 6 to be assembled and welded on the same support 2 or on different supports.

This variant has the advantage of making it possible to produce all the welds of the bumps 12 simultaneously.

Once the welds have been carried out, the glass substrate 8 is removed from the chip 6. This operation can be effected by peeling off the substrate 8, the force for holding the adhesive pads 8 being substantially lower than that of the welds of the bumps 12 on the connection interface.

The result of this operation is that the chip 6 is electrically and mechanically connected to the surface of the support 2. To protect the chip 6, a film 22 is applied to the exposed surface 6b of the chip, as shown in Figure 6. This film 22 can be produced by a simple impression of lacquer able to protect the circuit from climatic and mechanical stresses. The extent of the film 22 can be limited so as not to cover the interconnection pads 4a so that these can provide an ohmic contact. However, it can be envisaged forming the film 22 on a larger part of the support 2, or even over its entire surface, provided that a step of

masking the ohmic contact areas 4a or of removing material of the film 22 at these areas is provided.

The first embodiment is based on a so-called "contact" smart card, in the sense that it is designed to communicate with the outside through the ohmic contact areas 4a.

However, the method according to the present invention also lends itself to producing so-called "contactless" cards. These cards, used amongst other things for remote paying or access control systems, make it possible to establish communication at a distance by radio link between the outside and the chip or chips 6 of the card.

An example of such a card is depicted in Figure 8. The card 2 is provided with an antenna 24 having its ends 24a and 24b connected to contacts - here in the form of bumps 12 - provided for this purpose on the chip 6, as shown in Figure 9.

In the example, two connections are produced at the two ends 24a and 24b of the antenna 24 with two respective bumps 12 on the face 6a of the chip 6 produced in SOI technology turned towards the support, as with the first embodiment.

In the example, the welding is carried out by a beam 16 coming directly from a laser 14 mounted on a positioning robot 18, as described previously with reference to Figure 5. It is of course also possible to provide tooling with several optical paths 20 making it possible to effect welds in parallel, as described with reference to Figure 6.

The steps following on from the welding of the bumps 12 with their respective contact points 24a, 24b are the same as those described previously, notably with regard to the removal of the glass substrate 8 and the production of the protective film 22.

The invention is remarkable in that it makes it possible to produce chip assemblies mounted on very thin supports without having recourse to a cavity or other recess at the point on the support intended to receive the chip.

In the examples described, based on smart cards, it is notably possible to comply with the industrial standards ISO 7810 with regard to the maximum excess thickness allowed on the general plane of the card (currently fixed at 50 microns). This is because the total excess thickness due to the surface mounting of the assembly forming the communication interface 4, chip 6 and protective film 22 is broken down as follows:

- thickness of the metallisation forming the communication interface ≤ 30 µm;
- thickness of the chip 6 resulting from SOI technology as described in the patent document WO-A-989/02921 = 10 µm (5 µm for the active circuit + 5 µm for the bumps 12);
- thickness of the protective film = 5 to 15 µm.

The present invention lends itself to many variants.

Thus it should be noted that the chip 6 can be connected to forms of support other than the support 2 described above. It is in fact just as possible to fix the chip 6 to a single-face printed circuit (for example in roll form), to a grid without dielectric or to any other support able to integrate a chip 6 mechanically and electrically.

Moreover, the scope of the invention extends well beyond the field of smart cards. It can be implemented in all fields which have recourse to active circuits mounted on supports, notably data processing cards, flat-screen displays, etc.